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Evaluation of Fisheries Relating to Floodplain Restoration on the Cosumnes River Preserve

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Introduction

The worldwide alteration and degradation of aquatic ecosystems has stimulated interest in the multidisciplinary topic of stream restoration. Among the recent topics of research in stream restoration is the maintenance of the terrestrial aquatic interface through the restoration of shallow water habitats. There is a complexity of shallow water habitat types, including floodplain, tidal marsh, and shoal habitats, all of which function in distinct ways and cater to specific fish species. The loss of these habitats has been listed as a possible cause of population declines for several native species including chinook salmon, delta smelt, and splittail (Meng and Moyle 1995; Sommer and others 1997).

Floodplain habitats have many potential benefits to native fishes. The strongest link between food availability, food use, and growth rates of river fish is associated with the seasonal inundation of the floodplain (Schlosser 1991). This increased availability of organic matter and invertebrates during floods, along with the expansion of the physical habitat, results in increased food intake and growth rate and improved condition for most river fish (Schlosser 1991). It has also been suggested that floodplain habitats may play an important role in the spawning of some native fishes. The importance of floodplain habitat to the overall health of the Sacramento-San Joaquin basin has only recently been considered and its' preservation and creation is presently the focus of many State, federal, and private organizations.

In 1995, The Nature Conservancy began a plan of floodplain restoration on land adjoining the lower reach of the Cosumnes River. Initial restoration of this area included breaching levees and removing small parcels of farmland from production. Since 1995, further restoration efforts have included additional levee breaks, levee setbacks, and the reforestation of farmland. Within this area there is an abundant diversity of habitat ranging from farmland to old growth, riparian forest. This evaluation attempted to study a wide range of habitats during flood events to determine fish use.

Study Area

The Cosumnes River, a tributary to the Sacramento-San Joaquin Delta, contains no major dams or upstream impoundments and has a mostly natural, highly variable hydrograph. The study area is located adjacent to the Cosumnes River within the boundaries of the Cosumnes River Preserve. This large tract of land is owned and operated by several private and public agencies, including The Nature Conservancy, US Bureau of Land Management, Ducks Unlimited, and the California Departments of Fish and Game and Water Resources. These agencies have come together in an effort to conserve existing and create additional endangered valley habitats. The Cosumnes River Preserve is located just east of Interstate 5 near the town of Franklin (Figure 1).

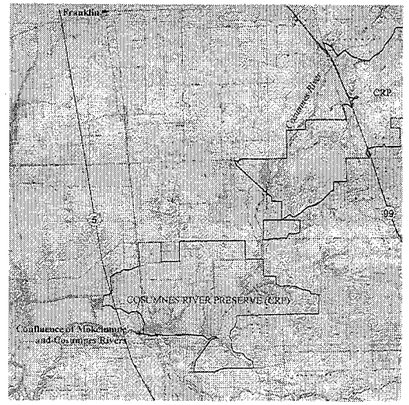

Figure 1 Geographical boundaries of the Cosumnes River Preserve, Galt, California

The Cosumnes River Preserve includes many types of habitat including fertile farmland, old growth, valley riparian forest, as well as land in various stages of wetland restoration. Ten sample sites were chosen within an area of the Cosumnes River Preserve that has been developed for seasonal flooding through the planned breaching of levees along the Cosumnes River (Figure 2).

Figure 2 Approximate locations of the ten sample sites in relation to the Cosumnes River and Wood Duck Slough in the Cosumnes River Preserve, Galt, California. The numbered red dots represent sample sites and the yellow bolts represent levee breaches.

METHODS

Sampling took place once a week, beginning 22 January and ending 22 May 1998, a total of 17 field days. Fish were sampled using a beach seine 10.5 m long and 1.2 m tall with 3.5 mm mesh. Two hauls were completed at each site when conditions permitted. Upon capture all fish were keyed to species, measured in millimeters (total length), observed for abnormalities, and released. All other organisms captured, including aquatic insects and amphibians, were recorded to species. Temperature, maximum depth, presence of flow, and cover were also noted. Voucher specimens were kept in instances where uncertainty existed in the original field identification. The California Department of Fish and Game Stream Evaluation Group verified all voucher specimens.

Fish captured during this study were broken down into two age classes to filter out spawning and rearing data. The first class contained young-of-the-year (YOY) fish less than one year old. The second class contained juveniles and adults that were one year and older. Age class designation was based upon size criteria for each species.

In March, YOY fish began appearing in our catches. Young-of-the-year, often caught in large numbers, are typically fragile and are subject to high mortality rates when handled. We decided that all YOY catches would be identified to species and estimated for abundance then released immediately to minimize post release mortality. Total lengths for YOY catches were recorded for chinook salmon only.

Fluctuating flows in the Cosumnes River caused water depths in the study area to change constantly. When river flows were high, overland flows through the study areas reached depths of up to 2.5 meters. Inversely, when flows in the river were low, water would drain off the floodplain resulting in some areas being dewatered. Consequently, during these periods of high and low flows various sites were not sampled due to flood or dry conditions.

RESULTS

Flows

From observations made throughout the study it was determined that flows of approximately 1,100 cubic feet per second (ft^3/s), recorded at the US Geological Survey gauging station at Michigan Bar, would allow water to flow into the upper levee breaches, thereby flooding the study area. Water began flowing into the study area on 14 January and continued to inundate at least some portions of the habitat until the conclusion of the sampling on 22 May.

Widely fluctuating flows in the study area limited sampling during each of the 17 field days, none of which included the sampling of all ten sites. The inability to sample various sites was caused by dewatered conditions on 7 of the 17 days and by flooded conditions for the remaining ten days. On six occasions, conditions at specific sites changed from dry to flooded or flooded to dry on consecutive sampling dates.

Species Composition

Eighteen species of fish were caught during this study. Of these six (33.3%) were native species and 12 (66.6%) were non-native.

Juveniles and adults of 16 species were captured. Inland silverside was the dominant species in this class accounting for 60% of all adult and juvenile fish. Other dominant species include Sacramento pikeminnow (18%), mosquitofish (9%) and golden shiner (6%).

Young-of-the-year of nine species were captured. Splittail were the dominant YOY species (67%) followed by Sacramento sucker (25%), inland silverside (2.3%), bluegill (1.9%), and chinook salmon (1.6%).

The complete list of species caught, including age class composition and the number of sites in which they were observed are listed in Table 1.

Table 1 Complete list of fish species caught in a beach seining study conducted within the Cosumnes River Preserve, Galt, California. The total number of each fish species captured and the number of sites in which they were observed are included.

Species	*Number of Adult and Juvenile Fish*	*Number of YOY Fish*	*Number of Sites*
Bigscale logperch (*Percina caprodes*)	10	37	3
Bluegill (*Lepomis macrochirus*)	1	62	4
Carp (*Cyprinus carpio*)	2	20	3
Chinook salmon (*Oncorhynchus tshawytscha*)[a]	0	52	7
Black Crappie (*Pomoxis nigromaculatus*)	7	0	4
Fathead minnow (*Pimephales promelas*)	2	0	1
Golden shiner (*Notemigonus crysoleucas*)	57	0	6
Goldfish (*Carassius auratus*)	4	0	3
Hardhead (*Mylopharadon conocephalus*)[a]	1	0	1
Inland silverside (*Menidia beryllina*)	547	74	9
Largemouth bass (*Micropterus salmoides*)	1	1	2
Prickly sculpin (*Cottus asper*)[a]	1	41	3
Redear sunfish (*Lepomis microlophus*)	25	2	8
Sacramento pikeminnow (*Ptychocheilus grandis*)[a]	162	0	8
Sacramento sucker (*Catostomus occidentalis*)[a]	1	790	9
Splittail (*Pogonichthys macrolepidotus*)[a]	0	2145	10
Threadfin shad (*Dorosoma petenense*)	6	0	3
Western mosquitofish (*Gambusia affinis*)	80	0	7
Total	907	3224	---

[a] Denotes native species

Site Specific Results

Site 1, located just inside the uppermost levee breach, contributed only 1.6% of the total fish caught and had the greatest number of hauls in which no fish were caught. Roughly one-third of the total number of hauls contained no fish. Successful hauls consisted of mainly salmon and small numbers of YOY sculpin.

Site 3, an area with no flow and warmer, stagnant water, yielded the largest numbers of YOY fish. Sixty-five percent of all YOY were captured at this site. Species composition at Site 3 was dominated by splittail (74%) and Sacramento sucker (26%).

Site 6, located adjacent to Wood Duck Slough, yielded the greatest species diversity, with 14 species observed over the study period. Seine hauls at this site produced 53% of the total number of all adults and juvenile fish and only 4.7% of the YOY observed over the study period.

Hauls at Site 7, located within a large, uniformly flooded field, yielded 23% of the adult and juvenile catch and 0.9% of the YOY total. Species composition of captures within this site was dominated by inland silverside (86%).

A summary of catch results and the physical attributes for each site is described in Table 2.

Chinook Salmon

During this study, 52 yearling chinook salmon ranging from 37 to 108 mm were captured. The first salmon was caught on 2 March and the last salmon was caught on 7 May. Salmon were caught in seven of the ten sites. Temperatures at the sites where salmon were caught ranged from 9 to 16.5 °C. Site 8, located in the oak forest, accounted for 37% of the salmon caught, while Site 1 accounted for 29% of the total catch. One yearling salmon caught contained a coded wire tag distinguishing it as a Mokelumne River fish.

Splittail

Splittail made up a large portion of the catch during this study. Although no juvenile or adult splittail were recorded, it was estimated that 2,145 YOY were captured, accounting for 52% of all fish caught in this study. Splittail were the only species captured in all ten sampling sites. Site 3 accounted for 72% of the total splittail caught.

Table 2 Species diversity and age structure in relation to physical habitat attributes at ten beach seining sites in the Cosumnes River Preserve, Galt, California.

		Total Number							Average Values	
Site	Days Sampled	Tows	Species	Adults and Juveniles	YOY	Substrate	Cover	Flow	Temperature (°C)	Depth (m)
1	17	33	7	13	52	Clay, fine sediment	No	Yes	11.4	0.32
2	9	24	12	8	162	Loam, vegetation	Yes	No[a]	14.2	0.47
3	17	30	11	31	2105	Loam, vegetation	Yes	No	13.4	0.46
4	13	22	8	15	177	Clay, fine sediment	No	Yes	14.4	0.48
5	10	16	8	51	292	Grass, vegetation	Yes	No	11.2	0.51
6	17	32	15	480	150	Grass, vegetation	Yes	No	15.9	0.42
7	7	13	6	209	28	Loam, vegetation	Yes	No	16.8	0.46
8	11	17	9	26	131	Vegetation	Yes	Yes	13.6	0.53
9	10	18	12	74	78	Vegetation	Yes	Yes	13.4	0.65
10	4	8	4	4	44	Vegetation	Yes	No[a]	14.0	0.64

[a] Flow was present only during significant overland flow conditions.

Invertebrates

The beach seine used in this study had 3.5 mm mesh, which allowed for the capture of aquatic invertebrates during routine sampling. Since most invertebrates, with time, could slip through the mesh, abundance numbers were not possible to calculate. Catches of invertebrates during regular sampling did allow for the general assessment of populations. During the initial sampling days it was noted that only red crayfish (*Procambarus* sp.) were present and that no aquatic insects were captured. On 9 February, approximately four weeks after the habitat was first flooded, the first aquatic insect, a backswimmer (Gerridae) was caught. Numbers of aquatic insects slowly began to increase. On 2 March, aquatic insects were captured in all sites and numbers remained high throughout the duration of the sampling. Aquatic insects captured included dipterans and odonate larvae. Red crayfish continued to be captured throughout the sampling period.

Discussion

The study area included a variety of habitat types. The physical attributes (depth, substrate, vegetation, flow) of each site varied considerably and, as might be expected a corresponding difference in species composition at each site was observed. Overall, the ratio of native species to non-native species was skewed in favor of the non-natives (33% to 66%, respectively), which compares with Harris (1996) who found that the species composition of the Cosumnes River was dominated by non-native species (70%). However, the individual numbers of native fish captured were higher than the individual number of non-natives accounting for 77% of the total catch. This suggests that comparing the ratio of the number of natives species against non-native species may not be the most accurate measure of the success or failure of shallow water habitat.

The Cosumnes River has historically had a variable population of chinook salmon, ranging from 0 to 5,000 (Harris 1996). Recent data suggest that the population has been in decline since the early 1970s (Reavis 1996). Possible reasons for this decline include factors affecting the adult population, including low outflow during up migration, barriers to upstream migration and inundation of spawning gravels with fine sediment. Conditions affecting juvenile chinook salmon on the Cosumnes River are much less understood. The abundance of juvenile salmon in streams is a function of many factors, including the quantity and quality of suitable habitat, abundance and composition of food, and interactions with other fish, birds, and mammals (Reiser and Bjorn 1979). Studies have shown that rearing chinook salmon are most commonly found in habitat with suitable amounts of space, habitat complexity in the form of brushy or large woody debris, adequate depth, flow, and temperatures ranging from 7 to 14 °C (Reiser and Bjorn 1979). In this study, 52 yearling chinook salmon were caught. Salmon were collected from 2 March through 7 May, which roughly corresponds to published migration times for fall-run chinook salmon (Stevens and Miller, 1983). Habitat in sites where salmon were captured ranged from furrowed farmland to oak forest. Temperatures at sites where salmon were caught ranged from 9 to 16.5 °C. In instances where the temperature exceeded the juvenile range, catches occurred in areas where cover nearby would allow relief from higher temperatures. Flow seemed to be much more critical than either habitat or temperature in determining if salmon were captured in a particular site. Sites 1, 4, 8, and 9 had some movement of water through the habitat except at times of extreme low flow and consequently catches in these sites made up 90% of the total salmon caught. Site 10, which accounted for three salmon, had current on the day salmon were caught. Site 8, the flooded forest location, possessed all of the essential physical attributes and, as a result, had the highest capture of juvenile salmon (37%).

On 23 April, an adipose-fin-clipped chinook salmon was captured in Site 8. The fish measured 94 mm (total length) and was captured along with a small school of non-tagged salmon ranging in size from 63 to 108 mm. Adipose fins are clipped on salmon smolts when a coded wire tag is inserted into their snout area, giving researchers a noticeable mark to distinguish between tagged and non-tagged fish. Once tagged smolts are captured the fish are sacrificed and the tags are removed and read. The East Bay Municipal Water District is currently overseeing research aimed at the chinook salmon population of the Mokelumne River. As part of this research, rotary screw traps are placed into the river to capture emigrating, hatchery and naturally produced salmon. Upon capture some fish are retained for coded wire tag insertion and promptly released back into the Mokelumne River. The fish captured in the study area was determined to be a natural production fish from the Mokelumne River. This information suggests that the fish swam down the Mokelumne River to its confluence with the Cosumnes River then proceeded approximately two miles up the main channel of the Cosumnes River into the area of flooded habitat. As noted earlier, very little is known about juvenile chinook salmon and their possible use of floodplain habitat for rearing; however, information gained from tagged fish will help provide the critical links needed between salmon rearing and flooded habitat use.

Splittail are thought to spawn in winter and spring on flooded vegetation (Sommer and others 1997). This information agrees with the data collected in this study. Although, no adult or juvenile splittail were captured, an abundance of YOY were caught throughout the study area. Splittail was the only species out of 18 total that were captured in each of the 10 sampling sites and were often caught in schools of several hundred fish. The first splittail YOY were captured on 23 March, coinciding with the appearance of aquatic invertebrates in the flooded habitat. Caywood (1974), and Meng and Moyle (1995) showed that terrestrial and aquatic invertebrates make up the typical diet for splittail. The literature suggests that the study area is providing both spawning habitat for adults and critical rearing habitat for larval YOY splittail.

Flow seemed to be an important factor in determining which species used which habitats. As noted earlier, 90% of all chinook salmon captured were in sites that always had some flow. Equally as noteworthy, splittail, though caught in all ten sites, were most abundant in sites where there was no or very little flow. Site 3, a site in which large numbers of splittail and Sacramento sucker YOY were captured, had no flow and in fact became stagnant during periods of low river flow. Site 7, which was surrounded by the largest body of water within the study area and typically had no flow, produced large numbers of inland silverside but low species diversity. The site accounted for only six species and possessed the lowest numbers of YOY fishes.

The stranding of fishes in floodplain habitats is considered a potentially serious problem. In some instances the benefits of a natural hydrograph and the accompanying favorable conditions are balanced with the increased risk of stranding. The stranding of fish is intrinsic in areas with variable flow conditions. Water depths in flooded habitats can fluctuate on a daily basis, potentially stranding fish located in areas where conditions allow for the puddling of water. Stranding can also occur as a result of poor drainage of the floodplain habitat. In this study several instances of stranding were recorded. On 16 March, a chinook salmon measuring 45 mm was captured in Site 4. The flows in the river were low in mid-March providing for dry conditions in many sites, including Site 4, which was reduced to a puddle measuring approximately 25 m by 10 m and 0.1 m deep. The otherwise healthy salmon was captured in this puddle. Other instances of stranding occurred in Sites 2, 3, 5, 6, 9, and 10 as well as in other

locations in the study area. Many of these stranded fish were mosquitofish, however, splittail, inland silverside, and carp were among other species observed in stranded conditions. Considering the serious implications to larval and juvenile fish, stranding needs further study along the Cosumnes River floodplain. Sampling once a week did not allow for sampling of areas suddenly dewatered by lower river conditions and should be included in any further study of the habitat.

Site 6 possessed the highest diversity of fish species and 53% of the total number of adult and juvenile fishes captured. The high diversity may easily be explained by the proximity of the site to Wood Duck Slough. It is assumed that many of the fish captured were permanent residents of the slough who temporarily used the inundated vegetation to feed. Therefore, observations made at this site may not be indicative of the ways fish use shallow water habitat.

The setback levee located near Sites 1, 2, 3, and 4 (see Figure 2) created adverse conditions for fish entering the system through the upper breach. The levee was originally designed to buffer the initial flux of flow through the new levee breach located near Site 1. Early in the season, as flows reached high levels, water flowed over the top of the setback levee, subjecting fish to stranding as flows receded. Later in the season, a large break occurred in the levee allowing a portion of the flow that entered the system through the top breach to flow north and east into areas where fish were subjected to areas of higher temperatures, increased potential for stranding, and less suitable habitats.

Conclusions and Recommendations

Shallow water habitat has become an important topic in the field of fisheries biology. Many researchers feel that the restoration of floodplains, including the continued development of shallow water habitat, is a key component of a healthy ecosystem for the Sacramento-San Joaquin Delta. Others cite a lack of data and question whether shallow water habitat can provide the spawning and rearing habitat needed by the threatened species residing in the Delta, while limiting populations of competing nonnative fish. All parties agree that additional research is needed to determine if shallow water habitat is part of the solution. Research on the subject is presently occurring in several locations, including a large study on the Yolo Bypass, a projected study at Prospect Island, and additional small projects located throughout the Delta. The Cosumnes River floodplain project is unique in that it is a non-tidal east Delta tributary and is relatively established compared to most current projects. It is therefore a noteworthy part of the continuing research of shallow water habitat.

This project intended to provide recommendations to improve the design and hydrology of the Cosumnes River floodplain. However, the unique, highly variable hydrology of the Cosumnes River made for a complicated system that changed daily. What might have been good for the system one day could have created a problem the next. What looked to be a warm, stagnant pool one day was teeming with threatened splittail the next. Additional research is needed before any large-scale recommendations could be proffered. Therefore, the following recommendations are separated into two groups: first, minor recommendations intended to improve habitat and eliminate stranding, and second, recommendations to improve future studies.

Physical Improvements

1. The setback levee located near the upper breach is problematic. Two possible solutions are offered. First, make additional breaches into the setback levee creating additional flow into the northeast side of the field. To accommodate this additional flow an upgrade to a larger standpipe would be needed for the outlet of the field into Wood Duck Slough. A second solution would be to simply remove the setback levee allowing the water to flow into the entire field and allowing it to drain at a more natural rate. This solution may require the strengthening of levees located north of the system.

2. A small irrigation valve located just inside the uppermost levee breach was often left open allowing water to flow from the vicinity of Site 1 under the setback levee into the area adjacent to Site 2. At low flow conditions this can potentially take fish out of a feeding eddy where many salmon gathered and carry them into an area where stranding can occur. This valve should always be closed.

Study Improvements

1. For many projects, sampling once a week is adequate. During this project, conditions changed so quickly that observing subtle changes was very difficult. Periods between weekly sampling often included several cycles of flooding and dewatering. These sampling inadequacies could be addressed by a shorter, more intense period of observation to record rapidly changing conditions as they occur, including depth and direction of flow at various locations.

2. Beach seining, although cost effective, did not allow for the sampling of all types of habitat within the system. A detailed study design, including the possible use of fyke traps, purse seines and electroshockers, would allow a greater ability to sample all types of aquatic habitat within the sample area.

3. Additional studies are needed to determine how and why fish are using the specific habitats within the system. These studies could include food utilization studies, an aquatic insect analysis, an in-depth, multihabitat larval fish analysis, and additional studies comparing cover and substrate types to fish abundance within the various habitats.

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